CONCLUSION

The effects of climate variability associated with the 1997-98 El Niño were widespread, and in many cases, socially and economically disruptive. Natural disasters attributed to the El Niño event included food shortages, population displacements, disease outbreaks, and large-scale environmental damage caused by floods, droughts, and fires. Unlike the 1982-83 El Niño, however, knowledge of the El Niño-Southern Oscillation, and predictions of its regional climatic effects were used to anticipate and, in some cases, mitigate negative impacts through prevention and preparedness measures. These successes were made possible through efforts by many international and national organizations, including NOAA-OGP, USAID-OFDA, IRI, NOAA-CPC, WMO, and numerous other international, national, and regional partners.

The NOAA-OGP international response to the latest El Niño was in part made possible through groundwork laid by the Pilot Program for the Applications of Climate Forecasts. Ongoing activities in Latin America, the Caribbean, Southeast Asia, the South Pacific, and Africa provided the background experience and contacts necessary to coordinate effective means for creating and communicating climate forecast information prior to El Niño-related floods and droughts. At the core of this response were the Climate Outlook Fora, venues at which climatologists and meteorologists created regional consensus precipitation forecasts and representatives from various sectors (e.g., disaster management, energy, water resources) discussed uses of climate information. These meetings were an important first step towards enhancing regional capacity to incorporate newly-available climate information into decision-making processes and in shaping the development of forecasting science according to user demands. For the first time, regional and international forecasting and applications communities were brought together around the problems of forecasting and planning for a specific El Niño event. In essence, the 1997-98 El Niño and anticipatory activities provided a chance for a "dry run" to learn how to apply this new climate forecasting skill and know-how in real world settings. Because of the scientific groundwork laid from TOGA onward and the continuing efforts of NOAA-OGP and its partners, the Outlook Fora were a significant component of the unprecedented international response to the El Niño event.

The Climate Outlook Fora and associated applications workshops demonstrated the need and potential for a long-term strategy for the generation, communication, and application of forecast information. It is hoped that the seeds of the Outlook Fora and applications activities will grow into regional climate forecasting networks which will provide regular, systematic climate information updates tailored to user needs in various regions around the world. The Pacific ENSO Application Center (PEAC), a pilot-project established to conduct research, produce information products, and perform outreach and education activities in response to ENSO-related climate variability in the U.S.-affiliated Pacific Islands, is one example of a centralized forecast dissemination institute tied into a regional network. NOAA-OGP, in cooperation with the Office of Foreign Disaster Assistance (USAID-OFDA) and international partners in South America, Central America, and the Caribbean, has also initiated the creation of a Pan-American Climate Information System (PACIS) for the production, distribution, and application of seasonal to interannual forecast information in the Americas. It is envisioned that PACIS will involve development of regional climate forecasting capabilities, transformation of forecasts into usable information for managers and decision makers, and training of both forecast users and producers on the creation, tailoring, and interpretation of climate projections. Signs of forecast networks are emerging in Southern Africa, as indicated by the continuation of the SARCOF process into 1998-99, and in Latin America, the Caribbean, and Southeast Asia, where many consensus forecasting activities similar to the Outlook Fora continue to occur.

In addition to the Outlook Fora, NOAA-OGP advanced the support and coordination of research programs related to climate and human health (the ENSO Experiment), social and economic impacts of climate change (the Economics and Human Dimensions Program), and the regional manifestations of global-scale climate variations and their effect on the dynamics of decision making in climate sensitive sectors in the United States (Regional Assessments Program). The ENSO Signal, a newsletter edited and distributed by NOAA-OGP, continued to highlight advances in forecast applications, new ENSO research techniques and scientific conclusions, and socioeconomic issues affected by ENSO.

As a specific response to the 1997-98 El Niño, NOAA-OGP activated the ENSO Rapid Response Project, a climate information clearinghouse for monthly and other periodic updates of climate-forecast and observation products for officials in the United States and abroad, and the California Pilot Project on the Use of Climate Information, to study whether and how climate information affected decision making in various sectors in California during the El Niño event. Both the California Pilot and ENSO Rapid Response projects will run through the La Niña event forecast for late 1998-99. NOAA-OGP developed a Web site specifically to provide access to the latest information on El Niño, in a format easily understandable to a variety of audiences, and supported the climate-information dissemination and application activities of Applied Research Centers around the country. In summary, NOAA-OGP programs during the latest El Niño were multi-sectoral, involved both research support and limited operational activities, and spanned state, regional, national, and international levels.

The full potential of evolving climate forecast capabilities will be realized only when climate forecasts are routinely and systematically applied to practical problems in multiple sectors, both public and private, and at different levels, from local to international. The mere existence of forecasts does not necessarily translate into effective adjustment actions until decision makers have determined how early-warning information can best be incorporated into the context of their requirements. Equally, developers of forecast systems need to be informed by users of these requirements, including optimal methods from the user perspective for providing and presenting information. Hence, a synergistic approach is required to ensure that forecast systems are created in as efficacious and practical a way as possible. This multidisciplinary dialogue was developed as part of the activities of NOAA-OGP and its partners during 1997-98. Given the cyclical nature of the El Niño Southern Oscillation (and forecasts for a La Niña event for 1998-99), it is clear that the types of severe floods and prolonged droughts associated with the most recent El Niño will occur in the future. The question, then, is not whether climate variability will continue, but whether or not populations around the world will be prepared. A critical component of this preparation will be the practical application of seasonal to interannual climate forecasts.

APPENDIX

ENSO Compendium: An Impacts Survey of Climate Variability and the Human System

ABSTRACT[42]

The NOAA Office of Global Programs began the ENSO Compendium during the 1997-98 warm event as a research project to document the interaction between human systems and the El Niño Southern Oscillation. As a compendium, the study provides preliminary impact descriptions that vary in level of detail. It is hoped that the end product — a compilation of anecdotal information on climate impacts — contributes insight into human-climate exchange.

The ENSO Compendium began with the belief that processes influencing the development and improvement of forecasts should, at least in part, be guided by the applicability of such information into strategic decisions. Although climate information is rarely the only variable factoring into a particular situation, it is nonetheless valuable to agriculturists, the energy sector, resource managers, aid workers, and a variety of other users. The ENSO Compendium, documents the socioeconomic impacts of the 1997-98 El Niño (and eventually the 1998-99 La Niña) in an attempt to contribute to the numerous efforts which make weather/climate information more applications-oriented.

Although the ENSO Compendium relies heavily upon datasets and reports of natural disasters in order to obtain a comparable reference and baseline, it should be noted that the research project is not trying to describe the relationship between human systems and catastrophe. Rather the emphasis is on climate variability. Fundamentally these are two very different concepts. Whereas the study of natural disaster covers only the extremes and negative impacts of climate and weather, climate variability attempts to address interaction. Climate variability captures disaster, abundance, and the adaptation of society. Perhaps data that describes the "tolerance" of human systems to climate variability is more valuable than that which documents when thresholds have been exceeded.

Data for the Compendium was compiled from a variety of news and wire services as well as country and international agency reports. A simple criterion was then applied to give rank and precedence to preferred references. In general a priority was given to reports from UN agencies or governments, academic journals, then wire services, then media, and finally NGO or corporate-produced figures. Once the data was filtered and assembled, region-specific trends as well as interregional relationships were identified.

For the study of the 1997-98 period, estimators used to measure negative impacts were: direct dollar loss, mortality, morbidity, persons affected, persons displaced or made homeless, acres affected, households affected, houses lost, villages/towns/cities affected, bridges/culverts destroyed or damaged, km of road damage/destroyed, assistance requested, relief aid given, prevention, and preparedness. Beneficial effects were described through anecdotal information due to poor reporting. Although the cost of the 1997-98 event was estimated at over $30 billion, the reader should not consider any single total a firm, unquestionable number. However, it is believed that many of the proxies do provide very useful information when used to look for trends in conjunction with other variables or across regions. For instance, a clear inverse relationship between regional mortality and monetary loss suggests that the impact of ENSO-type disasters is largely dependent upon the overall preparedness and development of a region (see Figure A). In combination with anecdotal information the same relationship between deaths and direct dollar loss also highlights possible reporting biases in certain areas.

From specific scenarios the ENSO Compendium is also able to speculate how climate variability

[42] The final version of the ENSO Compendium is scheduled to be finished in Fall 1999. However, interim drafts containing a full description of methodology and discussion of the limitations on data used in the report are available upon request.

might affect humans should current socioeconomic trends persist. As evident from the totals associated with the China floods, population and wealth density are extremely significant factors influencing impacts caused by climate variability. All of the monetary damage totaled by the study from June of 1997 to June 1998 equaled $33.2 billion (see Figure B). Over a forty-day period (from August 1, 1998, to September 11, 1998) a global tally of damage from flooding and drought equaled between $28 and $44 billion USD. Moreover, the number of people affected, injured, displaced, etc. overshadowed the totals produced for 1997-98. Damage from the China floods dominated the total cost of the August-September period. Estimates of direct monetary loss to China ranged from $20 billion to $36 billion.

The contrast between the losses of one particular year and a single month illustrates that impacts from climate variability require interaction between the environment and human systems. In this example, the difference between regional population density significantly polarized the magnitude of damage between the two samples. Even though China implemented excellent response strategies, the flooding was wide spread and affected areas of high population density such that the value of property and cost of protecting lives exceeded the global costs incurred during the 1997-98 El Niño.[43] If population size, placement, density, and wealth all significantly determine the degree to which climate variability impacts human society, then as populations grow and become more urbanized, and wealth centers consolidate, climate variability may have an even more pronounced influence on human systems in the future.

Aside from demographic and socioeconomic factors that influence the impact of natural variation, the ENSO Compendium also identifies a series of human activities that cause the local or regional environment to act as an "enhancer" of damage. Enhancers were identified as those pre-existing conditions or practices that effectively lowered the disaster threshold. For example, China openly acknowledged that logging practices increased the severity of the floods. Mexico also acknowledged that logging and illegal housing-development magnified the amount of damage incurred in Chiapas by flooding. This is not to say the flooding in the two countries would not have occurred if their forests had been left intact, but deforestation and other practices were suspected of increasing the amount of damage.

Much of the analysis performed as part of the ENSO Compendium was limited by a lack of baseline or reference data. In fact, aside from reporting totals and trends, a significant portion of the project is a review and identification of future research needs.

As a general rule the standardization of data collection and reporting of natural disasters is nearly nonexistent, and the few data series that do exist have not been running for much longer than a decade. Even the lengthier data sets are plagued by abrupt changes in the sources used, and inherently these various references report damages and benefits with differing resolution.

A list of several estimates of damage caused by climate and weather related to natural disasters is given in Figure C. As demonstrated by cost estimates listed by the World Disaster Reports of the International Federation of the Red Cross/Crescent, a ten-year survey of climate/weather related disasters yielded an average of $48 billion per year, whereas a five-year sample produced a ~$350 billion annual estimate. Such a discrepancy between annual losses illustrates the importance of temporal coverage. The ten-year period captured a more accurate depiction of costs by including years of little loss in addition to extreme years. The disparity also illustrates the extreme variability in the impacts felt from year to year. Another study that addressed the cost of natural disaster to the U.S. (National Science & Technology Council, 1997)

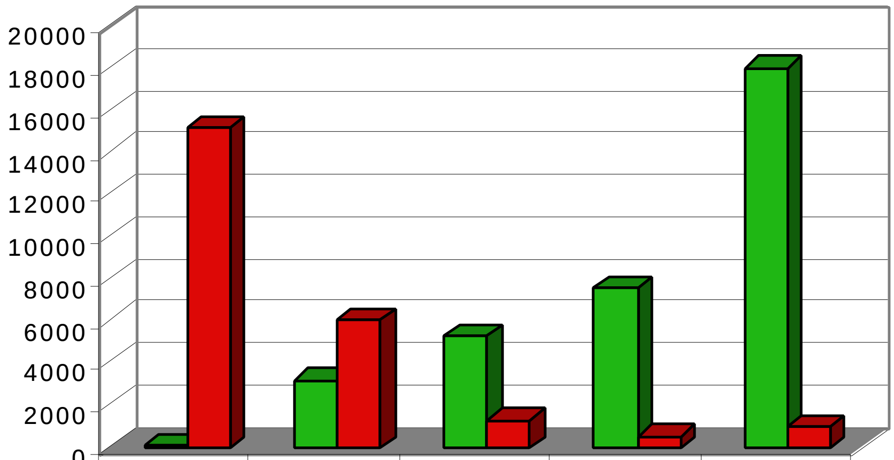
[43] Although 4,000 lives were lost to the floods in China, the number of causalities was exceeding low in comparison to the 223 million people affected or the 15.85 million made homeless.

provides an annual estimate of $54 billion from a sample of five years. It just so happens these five years cover some of the most costly hurricanes and earthquakes; in turn, these few extreme events dominate the cost totals. If the period under examination were lengthened or shifted, it is likely a very different annual estimate of damage would be produced.

Natural disaster datasets are also inherently tainted by a paradigm of how climate variability affects society. Data is almost always reported first in terms of monetary damage then lives lost — perhaps a tally of persons affected is included. Because these proxies are so few and rarely standardized between datasets, they are not enough to determine how humans interact with climate variations and extreme weather. At best these two or three proxies of global impacts can only identify that we are indeed affected by and exposed to climatic fluctuations. As more resolution is gained, however, by increasing spatial and temporal coverage coupled with a greater host of estimators, more resolution and better comprehension of relationships is gained. Some of the findings reported in the ENSO Compendium suggest that the scarcity of categories and ways of describing impacts is the reason data collection lacks standardization. For example, "affected" means very different things and captures many extremes (e.g., starvation vs. persons without power for a day). In addition, reported monetary losses or gains will differ depending upon the user or group documenting an event. Damages reported by insurance groups are very different from those of farmers, government aid agencies, NGOs, and also the private sector. Quite often, the difficulty of standardizing natural disaster data is filtering out expected or acceptable variation from losses or gains which exceed certain thresholds. When the cane industry reports damages associated with drought, do we report the expected increase in the cost of sugar, losses from individual farmers, or perhaps only increased subsidies?

Even though the ENSO Compendium addresses many of the limitations of data collection and information available, its own estimates are certainly not immune to similar pitfalls. As a study compiling and examining only two years of data, it is recognized that the estimates of direct dollar loss, mortality, etc. are representative of an extraordinary period. In addition, it is understood that the cost estimate of either El Niño or La Niña can be significantly driven up or down by redefining attribution of impacts to ENSO. Nonetheless, careful consideration and inclusion of many caveats does not distract from the results of the ENSO Compendium, rather it is hoped that the study provides a glimpse of the benefits associated with the implementation and application of climate data.

Figure A: Direct Dollar Loss vs. Mortality



	AFRICA	ASIA	INDONESIA & AUSTRALIA	NORTH AMERICA	MESO & S. AMERICA
DIRECT $ LOSS	118.3	3220	5330.8	7611.5	18068
MORTALITY	15246	6018	1317	542	997

Figure B: Global and Regional Impacts of the 1997-98 ENSO

REGION	DIRECT $ LOSS	MORTALITY	MORBIDITY	AFFECTED	DISPLACED	ACRES AFFECTED
AFRICA	118	15,246	107,301	10,400,000	2,217,500	478,638
ASIA	3,220	6,018	124,647	33,719,719	3,187,000	3,601,430
ASIA PACIFIC	5,331	1,317	57,546	66,113,666	90,000	7,031,199
NORTH AMERICA	7,612	542	Incomplete	41,100	400,000	31,708,300
S. & MESO AMERICA	18,068	997	243,743	723,033	363,500	13,868,065
GLOBAL TOTAL	34,349	24,120	533,237	110,997,518	6,258,000	56,687,632

DIRECT DOLLARLOSS EXPRESSED IN MILLION USD, WHILE ALLOTHER INDICATORS REPORTED IN ACTUALNUMBERS

Figure C: Costs Associated with Climate & Weather Related

An Illustration of Various Methodologies Used To Produce Impact Estimates

NOAA-OFFICE OF GLOBAL PROGRAMS SURVEY OF THE GLOBAL IMPACTS CAUSED BY THE 1997-98 ENSO WARM EVENT

- $33.2 billion USD (June to June Criteria)
- $~25 billion USD (Federally Recognized Disasters)

NYT ESTIMATE OFTHE GLOBAL MONETARY IMPACT FROM THE 1982-'83 ENSO WARM EVENT

- $21 billion USD (1997 dollars -- $13 billion USD in 1982-'83 dollars)

NOAA-OFFICE OF GLOBALPROGRAMS TALLY OF CLIMATE/WEATHERRELATED IMPACTS OCCURRING FROM AUGUST 1, 1998 TO SEPTEMBER 11, 1998

- $28.2 billion USD (using lower-end estimate of China floods)
- $44.2 billion USD (using upper-end estimate of China floods)

NATIONALSCIENCE AND TECHNOLOGY COUNCIL: MONETARY IMPACT OFALL NATURAL DISASTERS TO UNITED STATES

- $54 billion USD (annual average from 5yr survey)(~$1 billion USD per week)

INTERNATIONAL FEDERATION OFTHE RED CROSS/CRESANT REPORTED ESTIMATE OFANNUAL MONETARY LOSS ACCRUING FROM CLIMATE/WEATHER RELATED DISASTERS (from 1989-1993 sample) (1995 World Disasters Report)

- ~$350 billion USD

INTERNATIONAL FEDERATION OFTHE RED CROSS/CRESANT REPORTED ESTIMATE OFANNUAL MONETARY LOSS ACCRUING FROM CLIMATE/WEATHER RELATED DISASTERS (from 1987-1996 sample) (1998 World Disasters Report)

- ~$48 billion USD

MÜNCHENER RÜCK (Munich Reinsurance) 1997 ESTIMATE OF THE COST OF NATURAL CATASTROPHES

- $30 billion USD ($4.5 billion USD -- 15% -- covered by insurance)(represents all natural disasters)

MÜNCHENER RÜCK (Munich Reinsurance) 1996 ESTIMATE OF THE COST OF NATURAL CATASTROPHES

- $60 billion USD (represents all natural disasters)

ACRONYM GLOSSARY

ACMAD	-- African Center of Meteorological Applications for Development
ADPC	-- Asian Disaster Preparedness Center
ARCs	-- Applied Research Centers
ARPEGE-CLIMAT	-- Climate Research Project on Small and Large Scales (France)
BAKORNAS	-- National Coordinating Board for Disaster Management- Indonesia
BMRC	-- Australia Bureau of Meteorology
CATHALAC	-- Centro del Agua del Trópico Húmedo para América Latina y el Caribe (Panama)
CDC	-- Centers for Disease Control and Prevention (USA)
CERED	-- Vietnam Center for Environmental Research
CHAART	-- NASA-Center for Health Applications of Aerospace Related Technologies
CICERO	-- Centre for International Climate and Environmental Research (Norway)
CICESE	-- Centro de Investigacion Cientifica y Education Superior de Ensenada (Mexico)
CIRES	-- Cooperative Institute for Research in Environmental Sciences
CMI	-- Caribbean Meteorological Institute
COLA	-- Center for Ocean, Land, and Atmosphere Studies
CLIPS	-- Climate Information and Prediction Services Project
CLIVAR	-- Climate Variability and Predictability Programme
CMI	-- Caribbean Meteorological Institute
CPTEC	-- Center for Weather Prediction and Climate Studies (Brazil)
CU	-- Columbia University
DMC	-- Drought Monitoring Center
ECA	-- Economic Commission for Africa
ECMWF	-- European Centre for Medium-Range Weather Forecasts
ENRICH	-- European Network for Research in Global Change
ENSO	-- El Niño-Southern Oscillation
FSU	-- Florida State University
FSU-COAPS	-- Florida State University Center for Ocean-Atmosphere Prediction Studies
FUNCEME	-- Fundacao Cearense de Meterologia e Recursos Hiridicos (Brazil)
GCTE	-- Global Change and Terrestrial Ecology Programme
GHA	-- Greater Horn of Africa
GOALS	-- Global-Oceanic-Atmospheric-Land System

IAD	-- Intergovernmental Authority on Development
IAI	-- Inter-American Institute for Global Change Research
ICDDRB	-- International Center for Diarrhea Disease Research (Bangladesh)
ICIPE	-- International Center for Insect Physiology and Ecology
ICRISAT	-- International Crops Research Insitute for the Semi-Arid Tropics
ICSU	-- International Council of Scientific Unions
ICTP	-- International Center for Theoretical Physics
IFDC	-- International Fertilizer Development Center
IGBP	-- International Geosphere-Biosphere Programme
IGP	-- Instituo Geofisico de Peru
INPE	-- Instituto Nacional de Pesquisas Espacias (Brazil)
INPESCA	-- Instituto Peruano de Investigacioune Pesqueras
INRENARE	-- Instituto Nactional para Recursos Naturales Renovables (Panama)
IOC	-- Intergovernmental Oceanographic Commission
IRI	-- International Research Institute for Climate Prediction
IRRI	-- International Rice Research Institute
ITCZ	-- Inter-Tropical Convergence Zone
JHU	-- Johns Hopkins University
JIMAR	-- Joint Institute for Marine and Atmospheric Research, University of Hawaii
KMD	-- Kenya Meteorological Department
LSTM	-- Liverpool School of Tropical Medicine
MEDIAS	-- Reseau de recherche regionale sur les changements de l'environnetmen global dans le Bassin Mediterraneen et l'Afrique Subtropicale (France)
MPI	-- Max Planck Institute
NAO	-- North Atlantic Oscillation
NCEP	-- National Centers for Environmental Prediction
NGO	-- non-government organization
NIH	-- National Institutes of Health
NMHS	-- National Meteorological and Hydrological Services
NMRI	-- Naval Medical Research Institute
NOAA	-- National Oceanic and Atmospheric Administration

NOAA-CDC	-- NOAA's Climate Diagnostics Center
NOAA-CPC	-- NOAA's Climate Prediction Center
NOAA-ERL-AOML	-- NOAA-Environmental Research Laboratories Atlantic AOML Oceanographic and Meteorological Laboratory
NOAA-ERL-CDC	-- NOAA-Environmental Research Laboratories Climate Diasnostics Center
NOAA-OGP	-- NOAA's Office of Global Programs
NWS	-- NOAA's National Weather Service
NWS-PR	-- NOAA's National Weather Service Pacific Region
ODPEM	-- Office of Disaster Preparedness and Emergency Management (Jamaica)
OGP	-- NOAA's Office of Global Programs
OND	-- October-November-December
PACIS	-- Pan-American Climate Information System
PBDC	-- Pacific Basin Development Council
PDO	-- Pacific Decadal Oscillation
PEAC	-- Pacific ENSO Applications Center
PMEL	-- NOAA's Pacific Marine Environmental Laboratory
PNNL	-- Pacific Northwest National Laboratory
PNW	-- Pacific Northwest
PRESAO	-- Prevision Saisonniere en Afrique de l'Oest
RRP	-- ENSO Rapid Response Project
SADC	-- Southern Africa Development Community
SARCOF	-- South Africa Regional Climate Outlook Forum
SATCC	-- Southern African Transport and Communications Commission
SCPP	-- Seasonal-to-Interannual Climate Prediction Program
SIO-ECPC	-- Scripps Institution of Oceanography-Experimental Climate Prediction Center
SOI	-- Southern Oscillation Index
SPARCE	-- South Pacific Rainfall Climate Experiment
SPREP	-- South Pacific Regional Environmental Programme
SSG	-- Scientific Steering Group [of TOGA]
SSTs	-- Sea-Surface Temperatures
START	-- Global Change system for Analysis, Research, and Training

SVS	-- Standardized Verification System
TAO	-- Tropical Atmosphere-Ocean
TOGA	-- Tropical Oceans-Global Atmosphere Programme
UCD	-- University of California-Davis
UCR	-- Universidad de Costa Rica
UK-DFID	-- United Kingdom-Department for International Development
UKMO	-- United Kingdom Meteorological Office
UMD-CMB	-- University of Maryland-Center of Marine Biotechnology
UNCED	-- United Nations Conference on Environment and Development
UNDHA	-- United Nations Department for Humanitarian Affairs
UNDP	-- United Nations Development Programme
UOG-WERI	-- Water and Energy Resources Institute, University of Guam
USAID-FEWS	-- United States Agency for International Development - Famine Early Warning System
USAID-OFDA	-- United States Agency for International Development - Office of Foreign Disaster Assistance
USAPI	-- U.S.-Affiliated Pacific Islands
USDA-CMAVE	-- Department of Agriculture - Center for Medical, Agricultural & Veterinary Entymology
USDOD	-- U.S. Department of Defense
USDOI	-- U.S. Department of Interior
USDOS	-- U.S. Department of State
USF	-- University of South Florida
USFS	-- U.S. Forest Service
USGCRP-OSTP	-- U.S. Global Change Research Program - Office of Science and Technology Policy
USGS	-- U.S. Geological Survey
USP	-- University of the South Pacific
UW	-- University of Wellington, New Zealand
UWI	-- University of the West Indies (Jamaica)
UZ	-- University of Tanzania
WCRP	-- World Climate Research Programme

WERI	-- Water and Energy Resources Institute, University of Guam
WHO	-- World Health Organization
WHO-AFRO	-- WHO-Southern African Malaria Control Initiative
WMO	-- World Meteorological Organization
ZDMS	-- Zimbabwe National Early Warning Unit

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